PHOENIX
ENVIRONMENTAL SCIENCES

Detailed flora and vegetation survey for the Pilbara Regional Waste Management Facility

Prepared for Talis Consultants

April 2018

Final Report

Detailed flora and vegetation survey for the Pilbara Regional Waste Management Facility

Prepared for Talis Consultants

Final Report

Authors: [redacted]

Reviewer:

Date: 24 April 2018

Submitted to: [redacted]

Version history			
Name	**Task**	**Version**	**Date**
K. Crews	Draft for client comments	1	19 April 2018
K. Crews	Final submitted to client	0	24 April 2018

Phoenix Environmental Sciences Pty Ltd

1/511 Wanneroo Rd BALCATTA WA 6021

P: 08 6323 5410

E: admin@phoenixenv.com.au

Project code: 1192-PRW-TAL-BOT

Contents

CONTENTS I
LIST OF FIGURES II
LIST OF TABLES II
LIST OF APPENDICES II
EXECUTIVE SUMMARY III
1 INTRODUCTION 1
1.1 Survey objective and scope 1
1.2 Study area 1
2 LEGISLATIVE CONTEXT 3
2.1 Commonwealth 3
2.2 State 3
2.2.1 Threatened and Priority species 3
2.2.2 Threatened and Priority Ecological Communities 4
2.2.3 Significant flora and vegetation 4
2.2.4 Clearing of native vegetation 5
2.2.5 Environmentally Sensitive Areas 5
2.3 Introduced flora 5
3 EXISTING ENVIRONMENT 7
3.1 Interim Biogeographic Regionalisation of Australia 7
3.2 Land systems 7
3.3 Conservation reserves and Environmentally Sensitive Areas 7
3.4 Climate and weather 9
4 METHODS 10
4.1 Desktop review 10
4.2 Field survey 10
4.2.1 Quadrats and relevés 10
4.2.2 Targeted flora searches 12
4.2.3 Vegetation mapping 13
4.2.4 Condition mapping 13
4.2.5 Taxonomy and nomenclature 13
4.3 Survey personnel 14
5 RESULTS 15
5.1 Desktop review and reconnaissance survey summary (Phoenix 2017) 15
5.1.1 Conservation significant flora 15
5.1.2 Introduced flora 16
5.1.3 Vegetation associations 16
5.1.4 Threatened and Priority Ecological Communities 16
5.2 Field survey 17
5.2.1 Flora 17

5.2.2 Vegetation 19
5.3 Survey limitations 23
6 DISCUSSION 24
6.1 Flora and vegetation values 24
6.2 Commentary against the 10 clearing principles 24
7 REFERENCES 27

List of Figures

Figure 1-1 Project location and Study Area 2
Figure 3-1 IBRA subregions and land systems of the Study Area 8
Figure 3-2 Annual climate and weather data for Onslow Airport (no. 005017) (BoM 2018) and mean monthly data for the 12 months preceding the field survey 9
Figure 4-1 Survey sites 11
Figure 5-1 Significant flora records and vegetation types in the Study Area 18
Figure 5-2 Weed records and vegetation condition of the Study Area 22

List of Tables

Table 3-1 Description of land systems intersecting the Study Area 7
Table 4-1 Vegetation condition rating scale (Trudgen 1988, in EPA 2016c) 13
Table 4-2 Project team 14
Table 5-1 Conservation significant flora species identified from the desktop review (Phoenix 2017) 15
Table 5-2 Likelihood of occurrence for conservation significant flora 15
Table 5-3 Priority ecological communities identified in the desktop review 17
Table 5-4 Unidentified taxa recorded during the field survey 19
Table 5-5 Vegetation types recorded in the Study Area 21
Table 5-6 Survey limitations 23
Table 6-1 Commentary against the clearing principles 25

List of Appendices

Appendix 1 Survey site descriptions
Appendix 2 Weed species identified from the desktop review
Appendix 3 Flora species inventory (Phoenix 2017 and current survey)

EXECUTIVE SUMMARY

The Shire of Ashburton (the Shire) is seeking approval to develop the Pilbara Regional Waste Management Facility (the Project), located within Lot 150 Onslow Road, Thalanyji, approximately 32 kilometres (km) southeast of Onslow in the Carnarvon bioregion. In February 2018, Phoenix Environmental Sciences (Phoenix) was commissioned by Talis Consultants (Talis), on behalf of the Shire to undertake a detailed flora and vegetation survey of the 422.2 hectare (ha) site (the Study Area).

The aim of the survey was to build on the information collected in a reconnaissance flora and vegetation survey conducted for the Project in September 2017. The survey was undertaken from 27 February – 2 March 2018 and included surveying of quadrats and relevés, targeted significant flora searches, and vegetation type and condition mapping. Climatic conditions were very dry at the time of the survey.

Four vegetation types were mapped in Study Area, with some revisions made to the vegetation mapping during the reconnaissance survey. The majority of the Study Area comprised a Hummock Grassland 1, *Triodia basedowii* grassland (with isolated *Corymbia hamersleyana* and/or *C. zygophylla* mallee) on flat plain. Vegetation on a longitudinal sand dune in the Study Area was dominated by an Open Shrubland 1, *Grevillea stenobotrya* over *Quoya loxocarpa* in *Triodia schinzii* grassland interspersed by patches of Open Mallee Woodland.

The vegetation in the Study Area is considered to have low regional conservation significance. No Federal or State listed Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) are present and the vegetation types defined are representative of the broad vegetation association Hummock grasslands, shrub steppe; kanji over soft spinifex & *Triodia basedowii*, which is a widespread community well represented at a regional level.

In the current survey, 51 flora species and subspecies representing 17 families and 31 genera were recorded. When considering the results of both the current and reconnaissance survey, a total of 68 flora species and subspecies representing 19 families and 38 genera have been recorded from the Study Area. The most prominent families recorded were the Fabaceae (19), Poaceae (9), Malvaceae (7) and Proteaceae (5). Species richness ranged from 9–17 species between sites. Only one introduced species, **Cenchrus ciliaris*, was recorded.

No Commonwealth or State listed Threatened Flora were recorded during the survey. Two Priority Flora were recorded in the current survey that were also recorded in the reconnaissance survey. *Abutilon* sp. Pritzelianum (P1) was previously recorded in the reconnaissance survey from two locations (3 plants). These appeared to have perished in the current survey but are likely to persist as seed in the soil seedbank. An additional 37 plants (29 within the Study Area and eight outside) were recorded in the current survey that were tentatively identified as *Abutilon* ?sp. Pritzelianum. Dry conditions during the survey precluded definitive identification of the species.

A single plant of *Triumfetta echinata* (P3) recorded in the reconnaissance survey was re-located and found to have died, although the species may remain in this area as seed in the soil seedbank. Despite a thorough search of the surrounding area, no other individuals were found. The Study Area represents suitable habitat for a further three Priority flora identified in the desktop review (Phoenix 2017), *Abutilon* sp. Onslow (P1), *Eremophila forrestii* subsp. *viridis* (P3) and *Goodenia nuda* (P4) that may possibly be found in more favourable climatic conditions, following considerable rainfall events.

Over 90% of the vegetation in the Study Area was considered locally significant as habitat for significant flora; however, considering the vegetation represents a widespread vegetation association, habitat for the recorded Priority Flora is likely to be present extensively outside the Study Area.

1 INTRODUCTION

The Shire of Ashburton (the Shire) is seeking approval to develop the Pilbara Regional Waste Management Facility (the Project), located within Lot 150 Onslow Road, Thalanyi, approximately 32 km southeast of Onslow (Figure 1-1). In February 2018, Phoenix Environmental Sciences (Phoenix) was commissioned by Talis Consultants (Talis), on behalf of the Shire to undertake a flora and vegetation survey for the Project.

Phoenix (2017) undertook a reconnaissance flora and vegetation survey, and Level 1 targeted terrestrial fauna survey for the site in September 2017 to support applications to undertake initial hydrogeological and geotechnical investigations for the development of the Project.

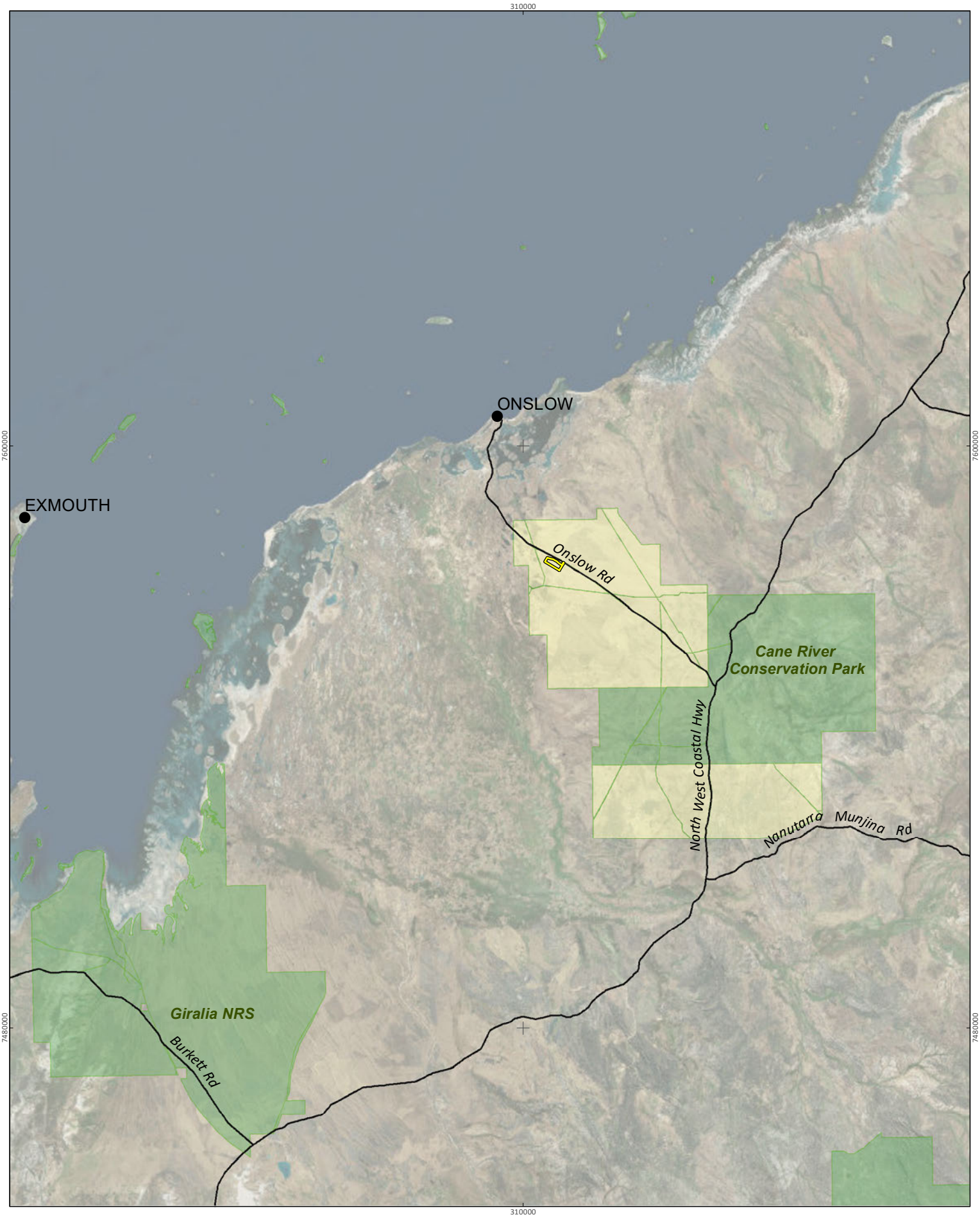
1.1 SURVEY OBJECTIVE AND SCOPE

The aim of the detailed flora and vegetation survey was to build on the information collected in the reconnaissance flora and vegetation survey Phoenix (2017) and included:

- a detailed, single phase field survey
- data analyses, sample processing and species identifications for samples collected during the field survey
- preparation of maps showing significant records, vegetation types and vegetation condition
- preparation of a technical report detailing the methods and results of the survey.

1.2 STUDY AREA

The Study Area was 422.2 hectares (ha) in size, consisting of a large rectangular polygon parallel to the Onslow Road with a narrow corridor for a proposed access road (Figure 1-1).



Talis Consultants

Pilbara Regional Waste Management Facility

Project No	1192
Date	4/18/2018
Drawn by	AL
Map author	GW

0 10 20 40

Kilometres

1:1,000,000(at A4) GDA 1994 MGA Zone 50

Study Area

Australian Protected Areas Database (CAPAD)

Australian Protected Areas Database (CAPAD)

Proposed addition to Cane River Conservation Park

Cane River (Mount Minnie and Nanutarra) NRS Addition

Figure 1-1

Project location and Study Area

PHOENIX ENVIRONMENTAL SCIENCES

2 LEGISLATIVE CONTEXT

The protection of flora and fauna in Western Australia (WA) is principally governed by three acts:

- *Commonwealth Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Western Australian Wildlife Conservation Act 1950* (WC Act)
- *Western Australian Environmental Protection Act 1986* (EP Act).

The WA *Biodiversity Conservation Act 2016* (BC Act) will eventually replace the WC Act; however, the provisions in the BC Act pertaining to the listing of flora and fauna cannot be brought into effect until the necessary Biodiversity Conservation Regulations have been made.

2.1 COMMONWEALTH

The EPBC Act is administered by the Federal Department of the Environment and Energy (DoEE). Under the EPBC Act, actions that have, or are likely to have, a significant impact on a Matter of National Environmental Significance (NES), require approval from the Australian Government Minister for the Environment through a formal referral process. The EPBC Act provides for the listing of threatened native flora and threatened ecological communities (TECs) as matters of NES.

Conservation categories applicable to Threatened Flora species under the EPBC Act are as follows:

- Extinct (EX)[1] – there is no reasonable doubt that the last individual has died
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium-term
- Conservation Dependent (CD)[1] – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation dependent taxon would be classified as
- Vulnerable or more severely threatened.

Ecological communities are defined as 'naturally occurring biological assemblages that occur in a particular type of habitat' (English & Blyth 1997). There are three categories under which ecological communities can be listed as TECs under the EPBC Act: Critically Endangered, Endangered and Vulnerable.

2.2 STATE

2.2.1 Threatened and Priority species

In WA, the WC Act provides for the listing of flora species which are under identifiable threat of extinction as specially protected (Rare or Threatened Flora and Threatened Fauna; T)[2]. Under

[1] Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

[2] This function of the WC Act will be replaced by the BC Act when the relevant BC Act regulations come into effect.

current classifications (Western Australian Government 2017), Threatened Flora are assigned to one of four categories (schedules):

- Schedule 1 (S1) – flora that are considered likely to become extinct or rare as Critically Endangered (CR) flora
- Schedule 2 (S2) – flora that are considered likely to become extinct or rare as Endangered (EN) flora
- Schedule 3 (S3) – flora that are considered likely to become extinct or rare as Vulnerable (VU) flora
- Schedule 4 (S4) – flora presumed to be extinct (EX).

The Department of Biodiversity Conservation and Attractions (DBCA) administers the WC Act and also maintains a non-statutory list of Priority Flora species (updated each year). Priority species are still considered to be of conservation significance – that is they may be rare or threatened – but cannot be considered for listing under the WC Act until there is adequate understanding of threat levels imposed on them. Species on the Priority Flora list are assigned to one of five priority (P) categories, P1 (highest) – P4 (lowest), based on level of knowledge/concern.

2.2.2 Threatened and Priority Ecological Communities

The Minister for Environment may list ecological communities, which are at risk of becoming destroyed as 'Threatened'[3]. DBCA maintains a list of ministerial-endorsed TECs which fall into three categories:

- Critically endangered (CR)
- Endangered (EN)
- Vulnerable (VU).

There is an additional category, Presumed Totally Destroyed, where all records of the ecological community within the last 50 years have been destroyed or presumed to be destroyed.

The DBCA also maintains a non-statutory list of PECs, which may become TECs in the future, however currently that do not meet survey criteria or that are not adequately defined. PECs are assigned to one of five categories depending on their priority for survey or definition, with Priority 1 of highest concern and Priority 5 of lowest concern.

2.2.3 Significant flora and vegetation

Flora and vegetation may be considered significant for a range of reasons, including, but not limited to the following (EPA 2016a):

- Flora:
    - being identified as threatened or priority species
    - locally endemic or association with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems)

[3] The BC Act will allow for the listing of TECs when the relevant BC Act regulations come into effect.

  - new species or anomalous features that indicate a potential new species representative of the range of a species (particularly, at the extremes of range recently discovered range extensions, or isolated outliers of the main range)
  - unusual species, including restricted subspecies, varieties or naturally occurring hybrids
  - relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.
- Vegetation:
  - being identified as threatened or priority ecological communities
  - restricted distribution
  - degree of historical impact from threatening processes
  - a role as a refuge
  - providing an important function required to maintain ecological integrity of a significant ecosystem.

2.2.4 Clearing of native vegetation

The clearing of native vegetation in WA is not generally permitted where the biodiversity values, land conservation and water protection roles of native vegetation would be significantly affected. Any clearing of native vegetation in WA requires a permit under Part V Division 2 of the EP Act, except where an exemption applies under the Act, or is prescribed by the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (the Regulations), and the vegetation is not in an Environmentally Sensitive Area (ESA). Permit applications to clear native vegetation require assessment against the '10 Clearing Principles', as outlined in the regulations.

2.2.5 Environmentally Sensitive Areas

Under section 51B of the EP Act the Minister for Environment may declare by notice either a specified area of the State or a class of areas of the State to be ESAs. ESAs are declared in the *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*, which was gazetted on 8 April 2005 (DMP 2008).

ESAs are areas where the vegetation has high conservation value. Several types of areas are declared ESAs including:

- the area covered by vegetation within 50 m of Threatened Flora, to the extent to which the vegetation is continuous with the vegetation in which the Threatened Flora is located
- the area covered by a TEC
- a defined wetland (Ramsar wetlands, conservation category wetlands and nationally important wetlands) and the area within 50 m of the wetland
- Bush Forever sites.

2.3 INTRODUCED FLORA

Introduced flora pose threats to biodiversity and natural values by successfully out-competing native species for available nutrients, water, space and sunlight; reducing the natural structural and

biological diversity by smothering native plants or preventing them from growing back after clearing, fire or other disturbance; replacing the native plants that animals use for shelter, food and nesting; and altering fire regimes, often making fires hotter and more destructive (AWC 2007).

Management of some weed species is required under Commonwealth or State frameworks. Key classifications for significant introduced flora that are relevant to this report are:

- Declared pest – the *Biosecurity and Agriculture Management Act 2007* (BAM Act), Section 22 makes provision for a plant taxon to be listed as a declared pest organism in parts of, or the entire State. Under the *Biosecurity and Agriculture Management Regulations 2013* declared pests are assigned to one of three control categories that dictate level of management required (DAFWA 2016)
- Weed of National Significance (WoNS) – high impact, established introduced flora causing major economic, environmental, social and/or cultural impacts in a number of states/territories, and which have strong potential for further spread (Australian Weeds Committee 2012). Management is required in accordance with Department of Primary Indiustries and Regional Development (DPIRD) guidelines for particular WoNS.

Throughout this report, introduced flora species are indicated with an asterisk (*).

3 EXISTING ENVIRONMENT

3.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Study Area is located in the Cape Range subregion (CAR1) of the Carnarvon bioregion (Figure 3-1), which covers an area of 8,430,172 ha (DEWHA 2008; Thackway & Cresswell 1995). It is also very close (~7 km) to the Roebourne subregion of the Pilbara bioregion.

The Cape Range subregion is characterised by (Kendrick & Mau 2001) as Quaternary alluvial, Aeolian and marine sediments overlying Cretaceous strata. A mosaic of saline alluvial plains with samphire and saltbush low shrublands, Bowgada low woodland on sandy ridges and plains, Snakewood scrub on clay flats, and tree to shrub steppe over hummock grasslands on and between red sand dune fields. Limestone strata with *Acacia stuartii* or *A. bivenosa* shrubland outcrop in the north, where extensive tidal flats in sheltered embayments support mangal.

3.2 LAND SYSTEMS

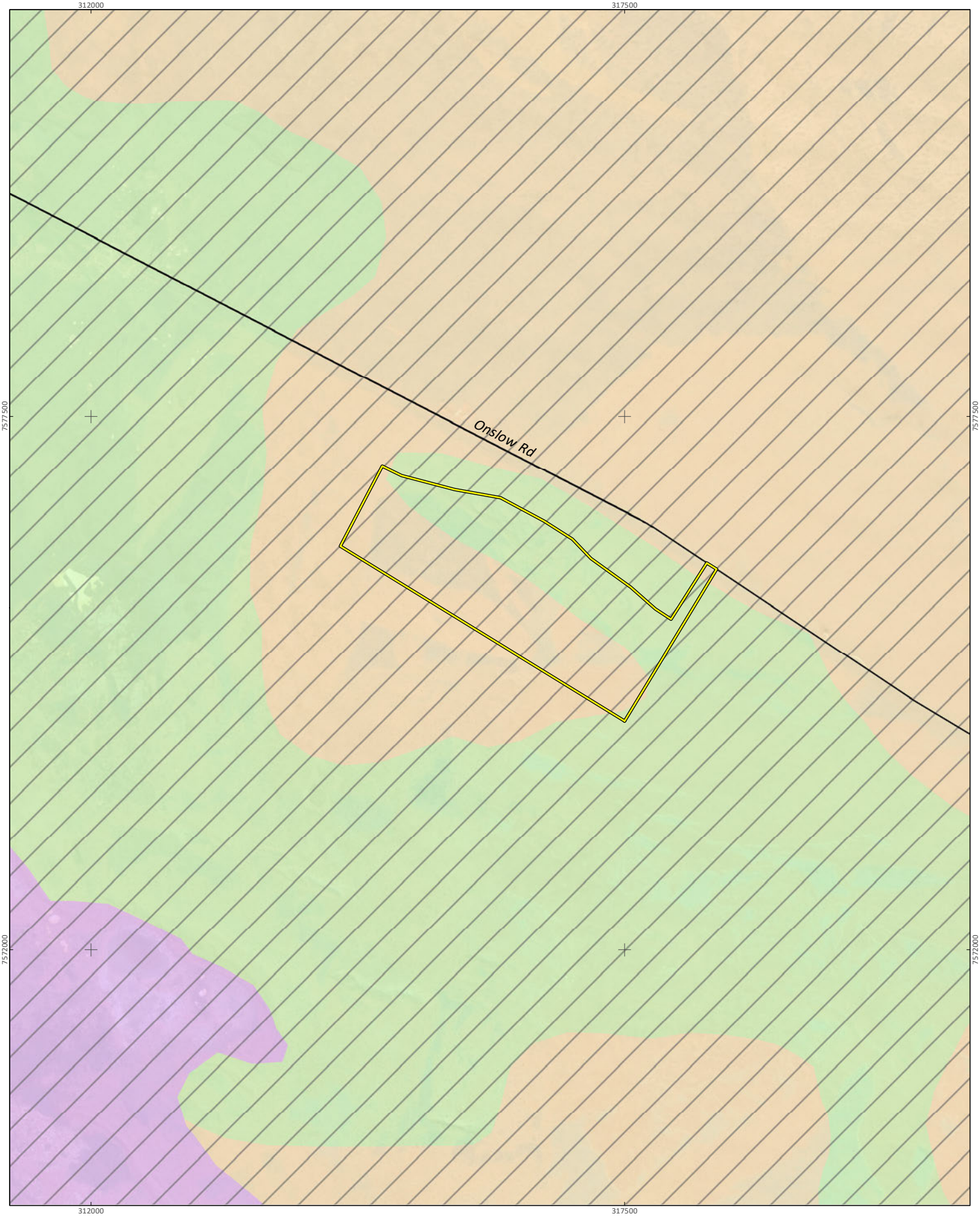
The Department of Agriculture and Food (DAFWA) has mapped the land systems of the Study Area as part of land system mapping of the Pilbara region (Payne & Leighton 2004). The Study Area intersects two land systems, the Giralia and Uaroo systems (Table 3-1; Figure 3-1).

Table 3-1 Description of land systems intersecting the Study Area

Land system	Land system description	Area (ha)	% of Study Area
Giralia	Linear dunes and broad sandy plains supporting hard and soft spinifex grasslands.	180.5	42.7
Uaroo	Broad sandy plains supporting shrubby hard and soft spinifex grasslands.	241.7	57.3

3.3 CONSERVATION RESERVES AND ENVIRONMENTALLY SENSITIVE AREAS

The Study Area is located within a DBCA managed land parcel designated as Unallocated Crown Land – former leasehold proposed for conservation (ex Mount (Mt) Minnie pastoral lease) (Figure 1-1). The former Mt Minnie Station is proposed to be added to the Cane River Conservation Park, located southeast of the Study Area, although the Project site will be excluded from this reserve addition.



Talis Consultants

Pilbara Regional Waste Management Facility

Project No	1192
Date	4/18/2018
Drawn by	AL
Map author	GW

0 0.5 1 2

Kilometers

1:50,000 (at A4) GDA 1994 MGA Zone 50

Study Area

Road

IBRA Region: Carnarvon

Subregion: Cape Range (CAR01)

Land system

Giralia System

Minderoo System

Uaroo System

Figure 3–1

IBRA subregion and land systems of the Study Area

PHOENIX ENVIRONMENTAL SCIENCES

3.4 CLIMATE AND WEATHER

The climate of the Cape Range subregion is described as arid, semi-desert to sub-tropical climate, with variable summer and winter rainfall (Kendrick & Mau 2001). Cyclonic activity can be significant, and cyclonic systems may affect the coast and hinterland annually (Kendrick & Mau 2001).

The nearest Bureau of Meteorology (BoM) weather station with comprehensive data collection and historic climate data is located at Onslow Airport (no. 005017, Latitude: -21.67°S Longitude: 115.11°E) approximately 28 km northwest of the Study Area. Onslow Airport records the average highest maximum mean monthly temperature (36.4°C) in January and February, the lowest maximum mean (25.4°C) in July (BoM 2017) (Figure 3-2). Highest minimum mean (25°C) is recorded in February and lowest (13.0°C) in July (BoM 2017) (Figure 3-2). Average annual rainfall is 314.4 mm with March and February recording the highest monthly averages (72.9 and 61 mm respectively).

Daily mean maximum and minimum temperatures for Onslow Airport in the 12 months preceding the survey (March 2017–February 2018) were similar to, or higher than, annual long-term averages except for February 2018, which had lower maximum temperatures than average (Figure 3-2). Rainfall in the months leading up to the survey was below long term annual averages, with only 83.8 mm recorded over the past year. In the three months prior to the survey, only 22 mm of rain was recorded (Figure 3-2).

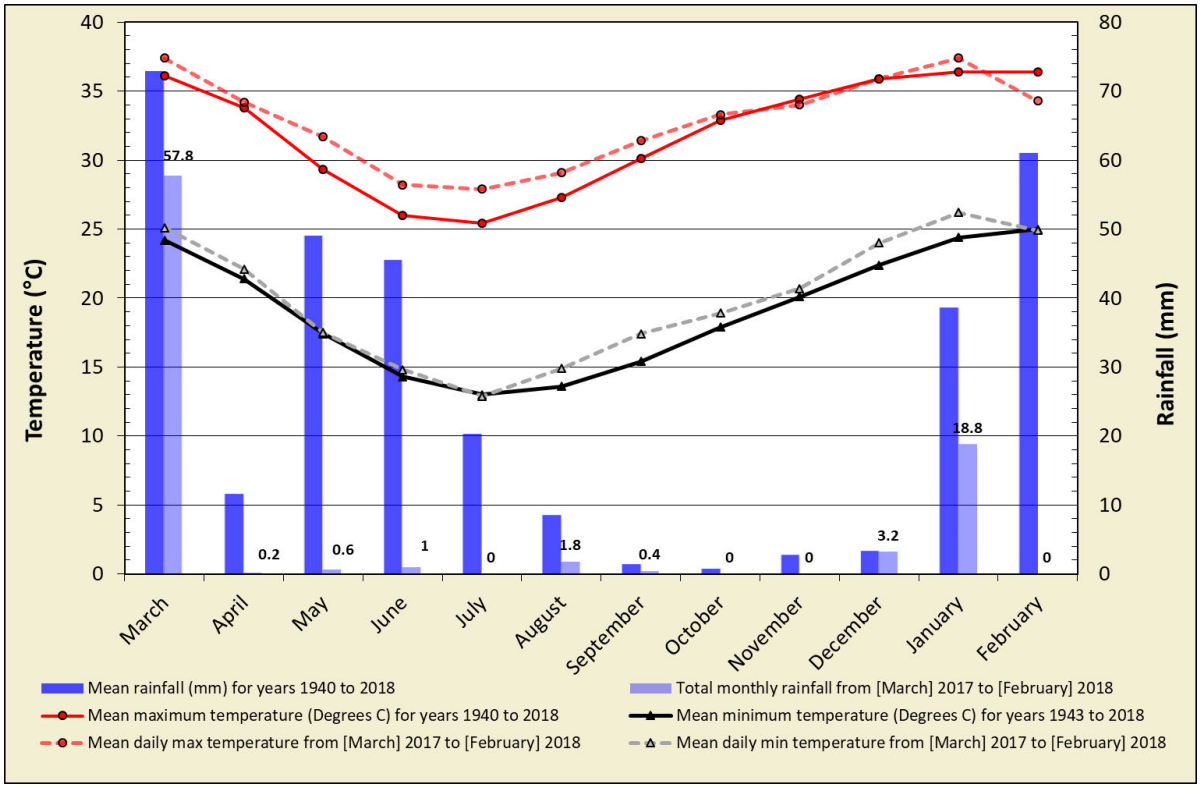


Figure 3-2 Annual climate and weather data for Onslow Airport (no. 005017) (BoM 2018) and mean monthly data for the 12 months preceding the field survey

4 METHODS

Survey design, methodology and report-writing adhered to relevant principles and guidelines, including:

- EPA *Statement of Environmental Principles, Factors and Objectives* (EPA 2016b)
- EPA *Environmental Factor Guideline: Flora and vegetation* (EPA 2016a)
- EPA *Technical Guidance: Flora and vegetation surveys for Environmental Impact Assessment* (EPA 2016c).

4.1 DESKTOP REVIEW

A desktop review was completed as part of the earlier flora and vegetation assessment (Phoenix 2017). This included searches of DBCA Threatened Flora, Fauna and Ecological Communities databases (DPaW 2017c), the EPBC Act Protected Matters Search Tool (DoEE 2017b) and the DBCA/WA Museum NatureMap database (DPaW 2017b), as well as a literature review. This review was utilised for the current assessment. In addition, the field results from the reconnaissance survey (Phoenix 2017) were incorporated into the desktop review results.

4.2 FIELD SURVEY

The field survey was undertaken from 27 February–2 March 2018. Field methods included:

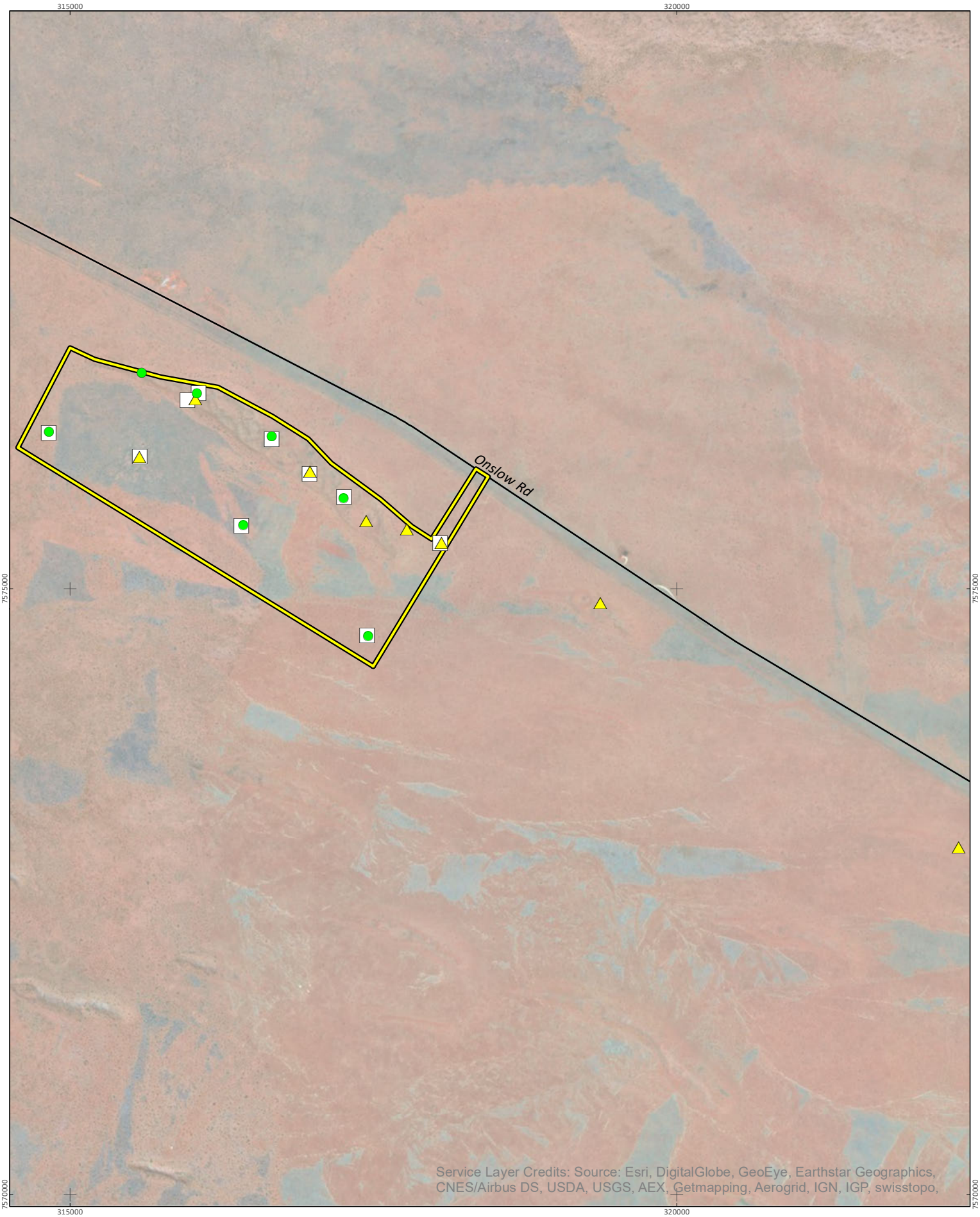
- surveying of quadrats and relevés (see section 4.2.1)
- targeted significant flora searches
- vegetation type mapping
- vegetation condition mapping.

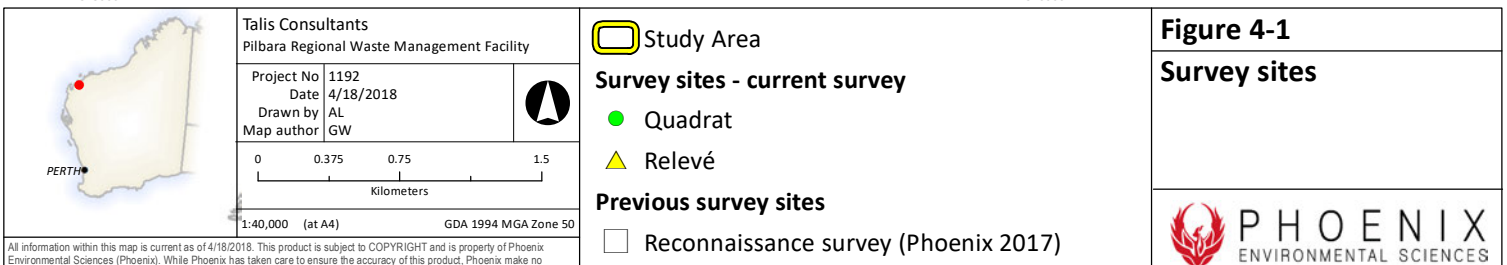
Prior to the commencement of the field survey, data including satellite imagery, survey boundary, previous vegetation type and condition boundaries, and locations of relevés sampled in the reconnaissance survey (Phoenix 2017) were loaded onto a digital tablet using the application GISPro version 3.18 (Garafa 2016). Survey data was recorded in the field in GDA 94 projection on a digital tablet, using Mobile Data Studio (MDS) version 8.0 (CreativityCorp 2016), and a Global Positioning System (GPS) device.

4.2.1 Quadrats and relevés

Most relevés from the reconnaissance survey (Phoenix 2017) were re-sampled as quadrats, and one additional quadrat and four relevés were sampled to ensure that an accurate representation of the major vegetation types identified by the reconnaissance survey were sampled adequately. Where possible, a minimum of three survey sites per vegetation unit were selected. Quadrats and relevés were accessed either by vehicle tracks or on foot.

In addition, three of the vegetation types, CzSsTb, GsQlTbTe and GsTvTbTe recorded on the sand dune in the reconnaissance survey and covering only a small extent were searched for outside of the Study Area to identify whether the recorded vegetation types occur in the broader landscape. Where a similar vegetation type was identified, a relevé survey was conducted and included photographs of the vegetation. In total, seven quadrats and eight relevés were recorded (Figure 4-1).





In accordance with the current technical guidance for flora and vegetation surveys (EPA 2016c), quadrat dimensions of 50 m x 50 m (2,500 m^2) were measured out with tape. The north-west corner was marked with a metal dropper. The following information was recorded for each quadrat and relevé (Appendix 1):

- unique site code
- location – the coordinates of each corner for quadrats and single point for relevés
- size and shape of quadrat and quadrat marking method
- description of vegetation – a broad description utilising the structural formation and height classes based on National Vegetation Information System (NVIS) (2003)
- habitat – a brief description of landform and habitat
- soil – a broad description of surface soil type and rocks
- disturbance history – a brief description of any observed disturbance including an estimate of time since last fire, weed invasions, soil disturbance and animal grazing
- vegetation condition – the condition of the vegetation utilising the condition scale for the Eremaean Botanical Province (EPA 2016c)
- height and foliage cover (quadrats) – a visual estimate of the canopy cover of each species as total vegetation cover, cover of shrubs and trees >2 m tall, cover of shrubs <2 m, total grass cover and total herb cover
- photograph of vegetation – in a south-easterly direction from north-west corner for quadrats, in the direction that best identified the vegetation type for relevés
- comprehensive species list including weeds (quadrats) – the name of every species present in the quadrat; where species unknown to survey personnel were located, or field identification was not certain, a specimen was collected and pressed for later identification at the state herbarium
- list of dominant flora species (relevés).

4.2.2 Targeted flora searches

Targeted searches were undertaken for significant flora throughout the study area. The searches occurred in all quadrats and relevés, as well as opportunistic sampling and meandering transect searches while traversing the Study Area. If a flora species was considered to potentially be a significant species (i.e. similar floristic characteristics and occurring within suitable habitat) the following information was collected:

- location (as GPS points for individual plants or as polygons for populations)
- description of the vegetation type and condition in which the species was located
- estimation of population size
- specimen collection for taxonomic identification and lodgement at the WA Herbarium, where possible
- map showing distribution within the Study Area and in the wider surrounds.

Concentrated effort was made in areas where populations of significant flora were identified in the reconnaissance survey to further quantify significant flora.

4.2.3 Vegetation mapping

The vegetation descriptions from the quadrats and relevés were grouped according to similarity of community structure (i.e. canopy levels), species composition and combination of species and the prevalent community structure (i.e. woodland, shrubland, etc.). The vegetation boundaries were mapped utilising ESRI aerial imagery (ArcGIS Desktop V10.5) and from vegetation boundaries recorded on GPS during the field survey.

4.2.4 Condition mapping

The condition of vegetation was mapped across the Study Area in accordance with the appropriate condition rating scale for the Eremaean Botanical Province where the Cape Range subregion is located (EPA 2016c). The vegetation condition ratings relate to vegetation structure, the level of disturbance and weed cover at each structural layer and the ability of the vegetation unit to regenerate. Vegetation condition ranges from 'Excellent' being the highest rating to 'Completely Degraded' as the lowest (Table 4-1).

Tracks and most of the newly installed bores (since the reconnaissance survey) were marked on the GPS.

Table 4-1 Vegetation condition rating scale (Trudgen 1988, in EPA 2016c)

Vegetation condition	Description
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

4.2.5 Taxonomy and nomenclature

Plant species were identified using local and regional flora keys including SPIKEY, the interactive key to *Triodia* spinifex grasses of the Pilbara, and comparisons with named species held at the WA Herbarium (M.D. *et al.* 2017). Nomenclature for flora and vegetation used in this report follows that used by FloraBase (DPaW 2017a) and the WA Herbarium. The conservation status of all recorded flora was compared against the current lists available on FloraBase (DPaW 2017a) and the EPBC Act Threatened species database provided by DoEE (2017a).

4.3 SURVEY PERSONNEL

The personnel involved in the survey are presented (Table 4-2).

Table 4-2 Project team

[redacted]	Qualifications	Role/s
	BSc. (Env. Biol.) (Hons)	Project management and report review
	BSc. (Cons. Bio., Bot.) (Hons)	Field survey
	PhD (Botany)	Flora taxonomy and report review
	PhD (Plant Con.)	GIS and vegetation mapping, data analysis and reporting
	BSc. (Env. Sci.)	Field survey and flora taxonomy

5 RESULTS

5.1 DESKTOP REVIEW AND RECONNAISSANCE SURVEY SUMMARY (PHOENIX 2017)

5.1.1 Conservation significant flora

Eight conservation significant flora species were identified from the desktop review (Phoenix 2017) as previously recorded within 40 km of the Study Area (Table 5-1).

Table 5-1 Conservation significant flora species identified from the desktop review (Phoenix 2017)

Species	Conservation status	Nearest record to Study Area
Abutilon sp. Onslow (F. Smith s.n. 10/9/61)	P1	~5.5 km west northwest
Abutilon sp. Pritzelianum (S. van Leeuwen 5095)	P1	~25 km north northwest
Helichrysum oligochaetum	P1	~40 km southeast
Eleocharis papillosa	P3	~15 km northwest
Eremophila forrestii subsp. *viridis*	P3	~6 km northwest
Stackhousia clementii	P3	~26 km north-northwest
Triumfetta echinata	P3	~11 km southeast
Goodenia nuda	P4	~38.5 west-northwest

No Commonwealth or State listed Threatened flora were recorded in the Study Area during the reconnaissance survey (Phoenix 2017) but Two Priority flora were recorded: *Abutilon* sp. Pritzelianum (P1) and *Triumfetta echinata* (P3) (Table 5-2; Figure 5-1). Based on habitats present, a further three of the six significant flora species identified in the desktop review were considered to have potential to occur in the Study Area (Table 5-2).

Table 5-2 Likelihood of occurrence for conservation significant flora

Species	Conservation status	Likelihood of occurrence
Abutilon sp. Pritzelianum	P1	Recorded in isolated low *Corymbia hamersleyana* and/or *C. zygophylla* mallee over isolated mixed shrubs over low *Triodia basedowii* hummock grassland in red sandy clay on sandplain.
Abutilon sp. Onslow (F. Smith s.n. 10/9/61)	P1	Likely, all vegetation types and soil types within the Study Area are suitable habitat.
Helichrysum oligochaetum	P1	Unlikely, lack of suitable soils (clay) and vegetation types (woodlands) and habitat (alluvial plains) in Study Area.
Eleocharis papillosa	P3	Unlikely, lack of suitable soils (clay) and habitat

Species	Conservation status	Likelihood of occurrence
		(clay pans) in Study Area.
Eremophila forrestii subsp. *viridis*	P3	Likely, majority of vegetation types and soil types within the Study Area are suitable habitat.
Stackhousia clementii	P3	Unlikely, lack of suitable soils (skeletal soils) and habitat (sandstone hills) in Study Area.
Triumfetta echinata	P3	Recorded in mid open *Grevillea stenobotrya* shrubland over low open *Tephrosia virens* shrubland over low *Triodia basedowii*, *T. epactia* and *Aristida holathera* grassland in red sand on sand dune.
Goodenia nuda	P4	Possible, occasionally recorded on red sand plain but typically recorded on floodplains which do not occur in the Study Area.

5.1.2 Introduced flora

The desktop review (Phoenix 2017) identified records for 25 introduced species within 40 km of the Study Area (Appendix 2), two of which are Declared Pests and WoNS **Parkinsonia aculeata* and **Prosopis pallida*. One introduced flora species, **Cenchrus ciliaris*, was recorded in the Study Area in the reconnaissance survey. The species is not a declared pest or WoNS.

5.1.3 Vegetation associations

Regional scale vegetation mapping by Shepherd *et al.* (2002, after Beard) mapped a single vegetation association, 98 Cape Yannare Coastal Plain in the Study Area defined as Hummock grasslands, shrub steppe; kanji over soft spinifex & *Triodia basedowii*. The reconnaissance survey (Phoenix 2017) found the vegetation types defined in the Study Area were representative of this broad vegetation association which is extensively represented in the Cape Range subregion and has over 99% extent remaining according to (Government of Western Australia 2017).

5.1.4 Threatened and Priority Ecological Communities

No Commonwealth or State listed TECs or DBCA listed PECs were identified in the desktop review (Phoenix 2017) as occurring within the Study Area. This was confirmed during the reconnaissance survey which concluded that no vegetation in the study area was representative of a TEC or PEC. Two Priority 1 PECs that were returned in the desktop review (Table 5-3) were related to land systems or vegetation associations that do not occur in the Study Area.

Table 5-3 Priority ecological communities identified in the desktop review

Community name	Description	Conservation status	Proximity to Study Area
Peedamulla Swamp Community	Peedamulla (Cane River) Swamp Cyperaceae community, near mouth of Cane River. Plants are unusual.	Priority 1	~36 km north-northeast
Tanpool Land System	A highly-restricted land system that occurs between Pannawonica and Onslow. Consists of stony plains and low ridges of sandstone and other sedimentary rocks supporting hard spinifex grasslands and snakewood shrublands	Priority 1	~40 km east-northeast

5.2 FIELD SURVEY

5.2.1 Flora

The conditions in the Study Area during the survey were extremely hot and dry reflecting no recent rainfall. Almost no herbs or annual species were observed and the majority of small plants were dead leaving desiccated remains for identification. Many of the living short-lived species were sterile making identification challenging.

Dry conditions were reflected in the number of species observed. In the current survey, 51 species and subspecies representing 17 families and 31 genera were recorded. When considering the results of both the current and reconnaissance survey, a total of 68 flora species and subspecies representing 19 families and 38 genera have been recorded from the Study Area (Appendix 3). Species richness for the combined survey results ranged from 9-17 species between sites (Appendix 1). The assemblage included 56 perennial species, six annual or short-lived species and six unknown life cycles due to the unidentified species. The most prominent families for the combined survey results were the Fabaceae (19), Poaceae (9), Malvaceae (7) and Proteaceae (5). One introduced species, **Cenchrus ciliaris*, was recorded.

5.2.1.1 Conservation significant flora

No Commonwealth or State listed Threatened species were recorded in the Study Area during the survey.

No new Priority species were recorded in addition to the two species found in the reconnaissance survey (Phoenix 2017). The *Triumfetta echinata* (P3) specimen found in reconnaissance survey (Phoenix 2017) was re-located but was dead. Despite a thorough search of the surrounding area, no other individuals were found.

A total of 37 plants (Figure 5-1) of an *Abutilon* sp. were located but all were sterile, and the majority were withered with few leaves or were dead. Of these, 29 occurred within the Study Area and eight were located outside. These plants are believed to be *A.* sp. Pritzelianum (P1); however, definitive confirmation was not possible. Specimens collected could be keyed out to two possible species *Abutilon lepidum* or *A.* sp. Pritzelianum but lacked any reproductive components and could therefore not be definitively identified to species level. As *A.* Pritzelianum was previously recorded at the Study Area the specimens have been identified as *A.* ?sp. Pritzelanium. The *A.* sp. Pritzelianum plants (positively identified) found during the reconnaissance survey (Phoenix 2017) could not re-located and appear to have perished.

Talis Consultants
Pilbara Regional Waste Management Facility

Project No	1192
Date	4/20/2018
Drawn by	AL
Map author	GW

0 0.4 0.8 1.6
Kilometers

1:42,000 (at A4) GDA 1994 MGA Zone 50

Study Area
Road

Vegetation type
ChAaTb, Hummock Grassland 1
ChAaTg, Hummock Grassland 2
CzAGTb, Open Mallee Woodland
GsQlTs, Open Shrubland 1
Disturbed Areas

Figure 5-1

Significant flora records and vegetation types from the Study Area

PHOENIX ENVIRONMENTAL SCIENCES

5.2.1.2 Introduced flora

One introduced flora species**Cenchrus ciliaris* was recorded in the survey at two locations (OWM01 and OWM08) (Figure 5-2). The species is not a declared pest or WoNS.

5.2.1.1 Range extensions

There were no range extensions for any of the flora species recorded.

5.2.1.2 Unidentified flora

A total of seven taxa could not be identified at the species level, in most instances as a result of insufficient taxonomic characters, as plants were sterile (lacking reproductive structures) (Table 5-4).

Table 5-4 Unidentified taxa recorded during the field survey

Unidentified taxon	Comments
Abutilon ?sp. Pritzelianum	Sterile
?*Cenchrus ciliaris* at OWM06	Sterile
Acacia sp. sterile	Sterile
Aristida sp. sterile	Sterile
Ptilotus ?*calostachyus*	Sterile
Tephrosia rosea ?var. *clementii*	Sterile
Trianthema ?*pilosum*	Sterile

5.2.2 Vegetation

5.2.2.1 Vegetation types

The current survey resulted in some revisions to the vegetation descriptions and vegetation type mapping undertaken in the reconnaissance survey (Phoenix 2017). Results of the reconnaissance survey indicated that the GsQlTbTe Open Shrubland may have restricted distribution and searches for this vegetation type were conducted outside of the Study Area during the current detailed survey. However, the collection of several species in the current survey that were not recorded in the reconnaissance survey at some sites resulted in this previously mapped vegetation type (GsQlTbTe: Open Shrubland 1) being removed as it was apparent this vegetation matched the more broadly defined vegetation type, GsQlTs: Open Shrubland 1, found on the sand dune. One additional vegetation type, ChAaTg, was delineated based on a previously unidentified *Triodia* species (*Triodia* ?*glabra*).

A total of four vegetation types were defined for the Study Area (Table 5-5; Figure 5-1). The majority (76.7%) of vegetation types comprised a Hummock Grassland 1 (ChAaTb), *Triodia basedowii* grassland (with isolated *Corymbia hamersleyana* and/or *C. zygophylla* mallee) on flat plain. Vegetation on the longitudinal sand dune was dominated by Open Shrubland 1 (GsQlTs), *Grevillea stenobotrya* over *Quoya loxocarpa* in *Triodia schinzii* grassland (15.1%) interspersed by patches of Open Mallee Woodland (CzAGTb) occupying 1.8% of the Study Area.

Vegetation recorded at two sites outside of the Study Area (OWMR01 and OWMR02) did not represent the vegetation types covering only a small extent within the Study Area identified in the reconnaissance survey (Phoenix 2017) but aligned with the dominant dunal vegetation (GsQlTs).

No major water bodies or drainage lines were observed in the Study Area.

5.2.2.2 Vegetation condition

The Study Area was assessed as being in excellent condition at the September 2017 reconnaissance survey (Phoenix 2017) with only one minor track present along the easement. Since then, more than ten underground water monitoring bores have been installed throughout the Study Area on the hummock plains and at the base and crest of the dune. As part of the installation, tracks have been graded to access the drill pads and there was subsequent damage to approximately 1.4ha (0.3%) of the vegetation.

Except for recently introduced tracks (rated as completely degraded), the condition of vegetation across the Study Area was excellent according to the applied condition scale (Figure 5-2) with small isolated scatterings of introduced species **Cenchrus ciliaris* and no erosion or evidence of grazing.

5.2.2.1 Threatened and Priority Ecological Communities

No vegetation types identified within the Study Area were classified as either a TEC or PEC.

5.2.2.2 Local and regional significance of vegetation

Two vegetation types defined in the current survey, Hummock Grassland 1 (ChAaTb) on flat plain and Open Shrubland 1 (GsQlTs) on sand dune were classified as locally significant as Priority Flora, *Abutilon* sp. Pritzelianum (S. van Leeuwen 5095, P1) and *Triumfetta echinata* (P3) were recorded in the reconnaissance survey (Phoenix 2017) in vegetation types originally defined on flat plain as ChCzTb and on sand dune as GsTvTbTe, and updated in the current survey to ChAaTb and GsQlTs respectively. *Abutilon* ?sp. Pritzelianum was recorded in the current survey on sand dune in vegetation type GsQlTs within the Study Area as well as on two separate sand dunes outside of the Study Area.

Table 5-5 Vegetation types recorded in the Study Area

Vegetation type	Site/s	Vegetation description	Extent in Study Area (ha)	Photograph
GsQlTs	OWM01 OWM02 OWM020 OWM021 OWMR01 OWMR02	**Open Shrubland 1** Tall open *Grevillea stenobotrya* shrubland over low open *Quoya loxocarpa*, *Acacia stellaticeps* and *Hibiscus brachychlaenus* shrubland over low *Triodia schinzii* grassland occasionally with *T. basedowii*.	63.83	
ChAaTb	OWM03 OWM04 OWM05 OWM07	**Hummock Grassland 1** Isolated low *Corymbia hamersleyana* and/or *C. zygophylla* mallee over isolated mid *Acacia ancistrocarpa*, *A. bivenosa* and *Grevillea* spp. shrubs over low *Triodia basedowii* hummock grassland.	323.51	
ChAaTg	OWM06	**Hummock Grassland 2** Isolated low *Acacia* sp. sterile, *A. coriacea* and *Corymbia hamersleyana* trees over isolated mid *Acacia ancistrocarpa*, *A. bivenosa* and *A. trachycarpa* shrubs over mid *Triodia ?glabra* hummock grassland.	27.35	
CzAGTb	OWM08 OWM022 OWM023 OWM024	**Open Mallee Woodland** Low open *Corymbia zygophylla* and *Corymbia hamersleyana* woodland over mid *Acacia* spp. and *Grevillea* spp. shrubland over low *Triodia basedowii* hummock grassland.	7.52	

Talis Consultants
Pilbara Regional Waste Management Facility

Project No	1192
Date	4/18/2018
Drawn by	AL
Map author	GW

0 0.175 0.35 0.7
Kilometers

1:20,000 (at A4) GDA 1994 MGA Zone 50

Study Area

△ *Cenchrus ciliaris*

Vegetation condition

Excellent

Completely Degraded

Figure 5-2

Weed records and vegetation condition of the Study Area

PHOENIX ENVIRONMENTAL SCIENCES

5.3 SURVEY LIMITATIONS

The limitations of the survey have been considered (Table 5-6) in accordance with EPA technical guidance (EPA 2016c, d).

Table 5-6 Survey limitations

Limitations	Limitation for this survey?	Comments
Competency/experience of survey personnel, including taxonomy	No	The field team and report authors have extensive experience in terrestrial flora and vegetation surveys within the region and across WA.
Scope and completeness	Yes	All target groups, significant species and habitats within the Study Area were surveyed. However, due to dry conditions some of the Priority Flora defined as potentially occurring in the Study Area may have been missed.
Intensity / effort and extent	No	The survey intensity was appropriate for the area surveyed and significant species targeted.
Proportion of flora identified, recorded and/or collected.	Yes	Due to extremely dry and hot conditions there were almost no herbs or annual species observed and the majority of small short-lived species were dead leaving desiccated remains for identification. Many of the living short-lived species were sterile making identification challenging.
Availability of adequate contextual information	No	The desktop review and reconnaissance survey (Phoenix 2017) provided adequate contextual information.
Timing, weather, season, cycle	Yes	There was very little annual rainfall preceding the survey and was below annual averages for a number of previous years.
Disturbances which affected the results of the survey	No	No disturbances occurred during the field survey which are considered to have impacted the results.
Remoteness and/or access problems	No	The whole of the Study Area was accessible by foot.

6 DISCUSSION

6.1 FLORA AND VEGETATION VALUES

All plants of the two Priority Flora recorded during the reconnaissance survey (Phoenix 2017), *Abutilon* sp. Pritzelianum (P1) and *Triumfetta echinata* (P3) had perished; however, the two species may remain in this area as seed in the soil seedbank. A further 37 plants tentively identified as *Abutilon* ?sp. Pritzelanium were recorded. The Study Area represents suitable habitat for a further three Priority flora identified in the desktop review (Phoenix 2017), *Abutilon* sp. Onslow (P1), *Eremophila forrestii* subsp. *viridis* (P3) and *Goodenia nuda* (P4) that may possibly be found in more favourable climatic conditions, following considerable rainfall events.

Abutilon sp. Pritzelanium is known from 45 records (DBCA 2018) with population sizes recorded ranging from 1 to 220 plants; however, the majority of records do not provide a population size. The species has been recorded in the Carnarvon, Murchison and Pilbara bioregions. The collection of eight *Abutilon* ?sp. Pritzelanium plants outside the Study Area indicates a wider distribution in the local area.

Triumfetta echinata is known from seven records (DBCA 2018) but no populations sizes are provided with any of the records. The species has been recorded in the Carnarvon, Gascoyne and Pilbara bioregions. The solitary plant of the species recorded in the Study Area during the reconnaissance survey was found to have perished in the current survey. Numerous fruit were observed at the base of the dead plant and subsequently it is likely that the species may still occur at this location as seed in the soil seed bank.

The vegetation in the Study Area is considered to have low regional conservation significance as no Federal or State listed TECs or DBCA listed PECs are present and the vegetation types defined are representative of the broad vegetation association Hummock grasslands, shrub steppe; kanji over soft spinifex & *Triodia basedowii* (Shepherd *et al.* 2002). Consequently, the vegetation in the Study Area represents a widespread community well represented at a regional level.

Over 90% of the vegetation in the Study Area was considered locally significant as habitat for significant flora; however, habitat for the recorded Priority Flora is likely to be present extensively outside the Study Area.

6.2 COMMENTARY AGAINST THE 10 CLEARING PRINCIPLES

Comments are provided on the potential for native vegetation clearing within the Study Area to be at variance with any of the clearing principles (Table 6-1).

Table 6-1 Commentary against the clearing principles

Principle	Statement against principle
A) Native vegetation should not be cleared if it comprises a high level of biological diversity	**Potential to trigger Principle A: unlikely** Vegetation in the Study Area is of low species diversity. The vegetation in the Study Area is representative of vegetation extensive throughout the CapeRange subregion. The vegetation of the Study Area does not comprise any PECs. Vegetation within the Study Area supports populations of Priority Flora; however, the vegetation is not an isolated remnant and is not diverse. Suitable habitat for *Abutilon* sp. Pritzelianum (Priority 1) is present. The species has as a wide distribution (Carnarvon, Murchison and Pilbara bioregions). Florabase lists 45 records with counts ranging from single individuals to more than 220 plants. Three confirmed and 29 tentative plants of the species have been recorded in the Study Area from vegetation types that are widely represented in the locality (Phoenix 2017; current survey). The species was also tentatively recorded at two locations outside the Study Area, indicating a wider distribution in the locality. Suitable habitat for *Triumfetta echinata* (Priority 3) is present. Species has a wide distribution (Carnarvon, Gascoyne and Pilbara bioregions). Florabase lists seven records. Only a single plant has been recorded in the Study Area (Phoenix 2017).
B) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia	**Potential to trigger Principle B: unlikely** The Study Area contains suitable habitat for nine significant fauna species. One of these has been recorded (Phoenix 2017) – Rainbow Bee-eater (Migratory). The Rainbow Bee-eater is a common and widespread species that occupies a broad range of habitat types. Therefore, the habitat in the Study Area is not considered significant for the species. Similar fauna habitat to that within the Study Area is extensively represented elsewhere more broadly on Mt Marion Station.
C) Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora	**Potential to trigger Principle C: unlikely** No rare (Threatened) flora species were recorded in the Study Area during either flora and vegetation survey.
D) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a Threatened Ecological Community (TEC)	**Potential to trigger Principle D: unlikely** No TEC is located within the Study Area.
E) Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has extensively cleared	**Potential to trigger Principle E: unlikely** The Study Area does not occur in an area that has been extensively cleared. The broad vegetation association mapped by Beard for the Study Area (Shepherd *et al.* 2002), association 98 – Hummock grasslands, shrub steppe; kanji over soft spinifex & *Triodia basedowii*, is extensively represented in the

	Cape Range subregion with 221,812 ha (nearly 100% of original extent) remaining based on Government of Western Australia (2017).
F) Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse of wetland	**Potential to trigger Principle F: unlikely** There are no watercourses or wetlands present in the Study Area.
G) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation	**Potential to trigger Principle G: unlikely** Clearing of a comparatively small area in the absence of water courses presents a low risk of excessive erosion that may cause land degradation.
H) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area	**Potential to trigger Principle H: possible** The Study Area is located within DBCA managed land parcel designated as Unallocated Crown Land – former leasehold proposed for conservation (ex Mt Minnie pastoral lease). The former Mt Minnie Station is proposed to be added to the Cane River Conservation Park, located southeast of the Study Area, although the Project site will be excluded from this reserve addition. Development of the Project will need to ensure appropriate onsite controls are implemented to prevent adverse impacts on the DBCA land parcel proposed to be transferred to the conservation estate.
I) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water	**Potential to trigger Principle I: unlikely** No surface water systems are present within or in the vicinity of the Study Area. Groundwater values were not covered under this scope of works.
J) Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding	**Potential to trigger Principle J: unlikely** There are no watercourses or wetlands present in the Study Area, therefore low potential to exacerbate the incidence of flooding.

7 REFERENCES

Australian Weeds Committee. 2012. *Weeds of National Significance 2012*. Department of Agriculture, Fisheries and Forestry, Canberra, ACT.

AWC. 2007. *The Australian Weeds Strategy. A national strategy for weed management in Australia*. Natural Resource Management Ministerial Council, Australian Weeds Committee, Canberra, ACT. Available at: http://www.environment.gov.au/biodiversity/invasive/weeds/publications/strategies/pubs/weed-strategy.pdf (accessed 20 November 2015).

BoM. 2017. *Climate statistics for Australian locations*. Commonwealth of Australia, Bureau of Meterology. Available at: http://www.bom.gov.au/climate/data/

BoM. 2018. *Climate statistics for Australian locations*. Commonwealth of Australia, Bureau of Meterology. Available at: http://www.bom.gov.au/climate/data/

CreativityCorp. 2016. *Mobile Data Studio 8.0*. CreativityCorp Pty Ltd, Manjimup, WA. Available at: https://www.creativitycorp.com/mds/ (accessed 8 April 2016).

DAFWA. 2016. *List of Declared Pests*. Department of Agriculture and Food, Perth, WA. Available at: https://www.agric.wa.gov.au/bam/western-australian-organism-list-waol

DBCA. 2018. *Florabase*. Department of Biodiversity, Conservation and Attractions. Available at: http://florabase.dpaw.wa.gov.au/

DEWHA. 2008. *Rangelands 2008 - taking the pulse. Dampierland bioregion*. Department of Environment, Water, Heritage and the Arts, Parkes, ACT. Available at: https://www.environment.gov.au/system/files/resources/a8015c25-4aa2-4833-ad9c-e98d09e2ab52/files/bioregion-dampierland.pdf (accessed 16 April 2015).

DMP. 2008. *Environmentally Sensitive Areas and Schedule 1 areas. December 2008*. Native Vegetation Assessment Branch, Department of Mines and Petroleum, Perth, WA.

DoEE. 2017a. *EPBC Act list of threatened flora*. Department of the Environment and Energy, Canberra, ACT. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora

DoEE. 2017b. *Protected matters search tool*. Canberra, ACT. Available at: http://www.environment.gov.au/epbc/protected-matters-search-tool

DPaW. 2017a. *Florabase*. Department of Parks and Wildlife, Perth, WA. Available at: https://florabase.dpaw.wa.gov.au/

DPaW. 2017b. *NatureMap*. Department of Parks and Wildlife, Perth, WA. Available at: https://naturemap.dpaw.wa.gov.au/default.aspx

DPaW. 2017c. *Threatened Flora, Fauna and Ecological Communities database searches*. Department of Parks and Wildlife, Kensington, WA.

English, V. & Blyth, J. 1997. *Identifying and conserving Threatened Ecological Communities (TECs) in the South West Botanical Province*. Department of Conservation and Land Management, Wanneroo, WA. ANCA National Reserves System Cooperative Program: Project Number N702.

EPA. 2016a. *Environmental Factor Guideline: Flora and vegetation*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Flora-Vegetation-131216_4.pdf (accessed 20 December 2016).

EPA. 2016b. *Statement of environmental principles, factors and objectives*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Statement%20of%20Environmental%20Principles%2C%20factors%20and%20objectives_Dec16_1.pdf (accessed 20 December 2016).

EPA. 2016c. *Technical Guidance: Flora and vegetation surveys for Environmental Impact Assessment*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EPA%20Technical%20Guidance%20-%20Flora%20and%20Vegetation%20survey_Dec13.pdf (accessed 20 December 2016).

EPA. 2016d. *Technical Guidance: Terrestrial fauna surveys*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Tech%20guidance-%20Terrestrial%20Fauna%20Surveys-Dec-2016.pdf (accessed 10 December 2016).

Garafa. 2016. *GIS Pro & GIS Kit*. Available at: http://garafa.com/wordpress/all-apps/gis-pro (accessed 7 April 2007).

Government of Western Australia. 2017. *2016 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of October 2016*. Department of Parks and Wildlife, Perth. Available at: https://www2.landgate.wa.gov.au/web/guest/downloader

Kendrick, P. & Mau, R. 2001. Carnarvon 1 (CAR1—Cape Range subregion). *In:* May, J. E. & McKenzie, N. L. (eds) *A biodiversity audit of Western Australia's 53 biogeographical subregions in 2002.* Department of Conservation and Land Management, Perth, WA, pp. 69–86.

M.D., B., B.M., A. & K.R, T. 2017. *SPIKEY: An interactive key to Triodia spinifex grasses of the Pilbara, Western Australia. Version 1.* Identic Pty Ltd, Brisbane. Available at: http://keys.lucidcentral.org/keys/v3/triodia/index.html

NVIS. 2003. *National Vegetation Information System — Australian vegetation attribute manual (version 6.0)*. Department to Environment and Heritage, Canberra. Available at: http://www.environment.gov.au/topics/science-and-research/databases-and-maps/national-vegetation-information-system

Payne, A. L. & Leighton, K. A. 2004. Land systems. *In:* van Vreeswyk, A. M. E., Payne, A. L., Leighton, K. A. & Hennig, P. (eds) *Technical Bulletin 9. An inventory and condition survey of the Pilbara region, Western Australia*. Department of Agriculture, Government of Western Australia, South Perth, WA, pp. 175–384.

Phoenix. 2017. *Flora and vegetation survey and terrestrial fauna survey for the Pilbara Regional Waste Management Facility*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Talis Consultants Pty Ltd.

Shepherd, D. P., Beeston, G. R. & Hopkins, A. J. M. 2002. *Native vegetation in Western Australia. Extent, type and status.* Department of Agriculture, South Perth, WA. Resource Management Technical Report 249.

Thackway, R. & Cresswell, I. D. 1995. *An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves, Version 4.0*. Australian Nature Conservation Agency, Canberra, ACT.

Western Australian Government. 2017. Wildlife Conservation Act 1950 - Wildlife Conservation (Rare Flora) Notice 2016. *Western Australian Governement Gazette* **4**: 69–76.

Appendix 2 Weed species identified from the desktop review

Family	Name	Declared Pest	WoNS
Amaranthaceae	**Aerva javanica* (Kapok Bush)		
Amaranthaceae	**Alternanthera pungens* (Khaki Weed)		
Arecaceae	**Phoenix dactylifera* (Date Palm)		
Asteraceae	**Conyza bonariensis* (Flaxleaf Fleabane)		
Asteraceae	**Flaveria trinervia* (Speedy Weed)		
Asteraceae	**Sonchus oleraceus* (Common Sowthistle)		
Asteraceae	**Tridax procumbens* (Tridax)		
Brassicaceae	**Brassica tournefortii* (Mediterranean Turnip)		
Convolvulaceae	**Ipomoea quamoclit* (Cupid's Flower)		
Euphorbiaceae	**Euphorbia hirta* (Asthma Plant)		
Fabaceae	**Leucaena leucocephala* (Leucaena)		
Fabaceae	**Parkinsonia aculeata* (Parkinsonia)	●	●
Fabaceae	**Prosopis pallida* (Mesquite)	●	●
Fabaceae	**Vachellia farnesiana* (Mimosa Bush)		
Malvaceae	**Gossypium hirsutum* (Upland Cotton)		
Malvaceae	**Malvastrum americanum* (Spiked Malvastrum)		
Onagraceae	**Oenothera laciniata* (Evening Primrose)		
Poaceae	**Avena barbata* (Bearded Oat)		
Poaceae	**Cenchrus ciliaris* (Buffel-grass)		
Poaceae	**Chloris barbata* (Purpletop Chloris)		
Poaceae	**Digitaria ciliaris* (Summer Grass)		
Poaceae	**Setaria verticillata* (Whorled Pigeon Grass)		
Portulacaceae	**Portulaca pilosa* (Djanggara)		
Rhamnaceae	**Ziziphus mauritiana* (Zornia)		
Solanaceae	**Solanum nigrum* (Black Berry Nightshade)		

Appendix 3 Flora species inventory (Phoenix 2017 and current survey)

Family	Species
Aizoaceae	*Trianthema ?pilosum*
Aizoaceae	*Trianthema pilosum*
Amaranthaceae	*Ptilotus astrolasius*
Amaranthaceae	*Ptilotus axillaris*
Amaranthaceae	*Ptilotus fusiformis*
Amaranthaceae	*Ptilotus nobilis*
Asteraceae	*Streptoglossa liatroides*
Asteraceae	*Streptoglossa macrocephala*
Chenopodiaceae	*Maireana melanocoma*
Cleomaceae	*Cleome uncifera* subsp. *uncifera*
Convolvulaceae	*Bonamia erecta*
Euphorbiaceae	*Adriana tomentosa*
Euphorbiaceae	*Adriana tomentosa* var. *tomentosa*
Fabaceae	*Acacia ancistrocarpa*
Fabaceae	*Acacia bivenosa*
Fabaceae	*Acacia coriacea*
Fabaceae	*Acacia* sp. sterile
Fabaceae	*Acacia stellaticeps*
Fabaceae	*Acacia synchronicia*
Fabaceae	*Acacia trachycarpa*
Fabaceae	*Acacia xiphophylla*
Fabaceae	*Indigofera colutea*
Fabaceae	*Isotropis atropurpurea*
Fabaceae	*Petalostylis cassioides*
Fabaceae	*Senna artemisioides*
Fabaceae	*Senna glutinosa* subsp. *glutinosa*
Fabaceae	*Senna glutinosa* subsp. *pruinosa*
Fabaceae	*Tephrosia rosea* ?var. *clementii*
Fabaceae	*Tephrosia rosea* var. *clementii*
Fabaceae	*Tephrosia* sp. Onslow (K.R. Newbey 10571)
Fabaceae	*Tephrosia uniovulata*
Fabaceae	*Tephrosia virens*
Goodeniaceae	*Goodenia microptera*
Goodeniaceae	*Scaevola sericophylla*
Goodeniaceae	*Scaevola spinescens*
Gyrostemonaceae	*Codonocarpus cotinifolius*

Family	Species
Gyrostemonaceae	*Gyrostemon ramulosus*
Hemerocallidaceae	*Corynotheca pungens*
Lamiaceae	*Dicrastylis cordifolia*
Lamiaceae	*Quoya loxocarpa*
Lamiaceae	*Quoya paniculata*
Malvaceae	*Abutilon* ?sp. Pritzelianum
Malvaceae	*Abutilon* sp. Pritzelianum (S. van Leeuwen 5095) (P1 WC Act)
Malvaceae	*Corchorus sidoides* subsp. *vermicularis*
Malvaceae	*Gossypium australe*
Malvaceae	*Hannafordia quadrivalvis* subsp. *recurva*
Malvaceae	*Hibiscus brachychlaenus*
Malvaceae	*Triumfetta echinata* (P3 WC Act)
Myrtaceae	*Corymbia hamersleyana*
Myrtaceae	*Corymbia zygophylla*
Myrtaceae	*Verticordia forrestii*
Plantaginaceae	*Stemodia* sp. Onslow (A.A. Mitchell 76/148)
Poaceae	?**Cenchrus ciliaris*
Poaceae	*Aristida holathera*
Poaceae	**Cenchrus ciliaris*
Poaceae	*Eragrostis eriopoda*
Poaceae	*Eriachne aristidea*
Poaceae	*Eriachne gardneri*
Poaceae	*Triodia ?glabra*
Poaceae	*Triodia basedowii*
Poaceae	*Triodia schinzii*
Proteaceae	*Grevillea berryana*
Proteaceae	*Grevillea eriobotrya*
Proteaceae	*Grevillea eriostachya*
Proteaceae	*Grevillea stenobotrya*
Proteaceae	*Hakea chordophylla*
Scrophulariaceae	*Eremophila glabra*
Solanaceae	*Solanum lasiophyllum*